HOMSC14

WG 1: HOM Damping Requirements Summary

07/17/2014

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Talks on HOM Damping Requirements

1. **XFEL HOM Specifications**
   Speaker: Alexey Sulimov (DESY)
2. **HOMs and wakes in LCLS-II Superconducting linac**
   Speaker: Karl Bane (SLAC)
3. **Overview of HOM damping in deflecting cavity**
   Speaker: Binping Xiao (Brookhaven National Lab)
4. **Physics of wake potentials of very short bunches**
   Speaker: Gennady Stupakov (SLAC)
5. **Resonance HOM excitation in LCLS-II**
   Speaker: Alexander Sukhanov (FNAL)
6. **HOM-free deflecting cavity**
   Speaker: Timergali Khabiboulline (FNAL)

General Remarks

- Landscape of SC projects is shifting to CW operation
  - *LCLS-II; CD1 approval, CD2/3 in 2015*
    - *300 cavities/35 CM's, incl. two 3.9GHz*
  - *XFEL considering upgrade for cw/high DF (~800 cavities)*
  - *JLAB 12 GeV upgrade*
  - *XFEL R&D and demonstration phase*
  - *PIP-II is avenue direction at FNAL supported by DOE*
  - *ESS, etc…*

- In this workshop major part of discussed topics in WG1 were focused on CW operation issues. We believe that in future more attention and efforts will be dedicated to understand better HOM requirement and limitations and develop the tools for the HOM analysis in complex systems:

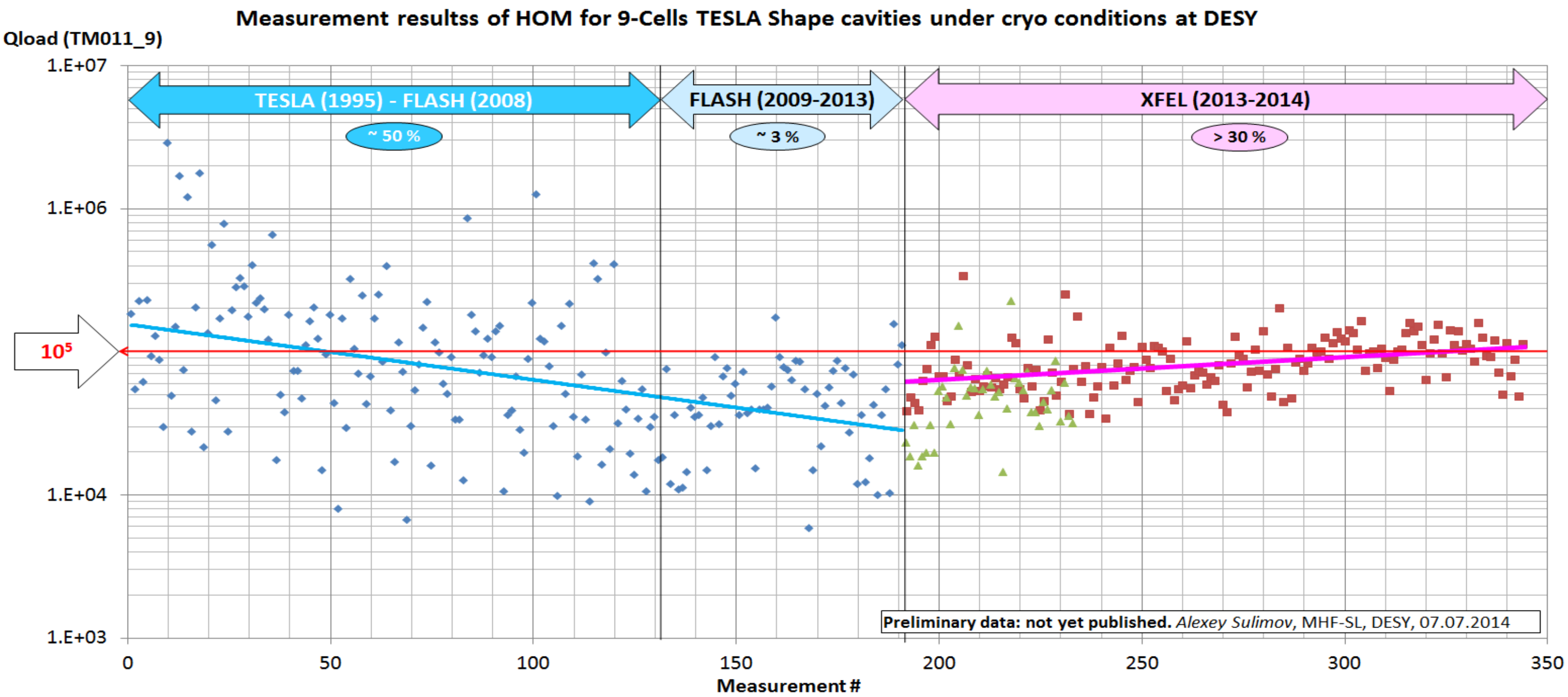
  - *Wakes for ultra-short bunches < 25 microns*
  - *HOM simulations for whole linac*
  - *Developed software for error analysis*
  - *Etc…*

Talks on HOM Damping Requirements

1. XFEL HOM Specifications - Alexey Sulimov (DESY)

Main message from the talk:

- HOM damping for dangerous TM011 mode of XFEL production cavities shows degradation vs. time. This can be attributed to relaxed tolerances on geometry.
- Damping approaches limit of $2\cdot10^5$, which was already increased by factor of 2 as compared to the previously achieved values for FLASH and pre-series cavities.
- Discussion with beam dynamic group is necessary to decide if this is tolerable.



Talks on HOM Damping Requirements

2. HOMs and wakes in LCLS-II Superconducting linac - Karl Bane (SLAC)

Topics discussed and main message:

HOM Power Loss

I. The beam (Q = 300 pC, frep = 1 MHz, σ_z = 25 µm) loses:
7.7, 10.7, 13.8 W/CM in L1, L2, L3 (29.5W and 14.5W in the 1st and 2nd CM)

II. HOM spectrum generated by the beam in L3 reaches **4 THz**
ca. 50% of the power is above 100 GHz, 35% above 1 THz, 15% above 2 THz

III. Beam pipe transitions (1 cm ↔ 3.9 cm) at ends of L3 generate **46W**

IV. 3rd harmonic CMs generate 2x 13W = **26W**

V. CSR at the last bend of B2 bunch compressors (with transient) is **110 W.**
Q: how much will be dissipated in SC linac?

VI. All SS surfaces will be **Cu – coated to reduce cryogenic losses**

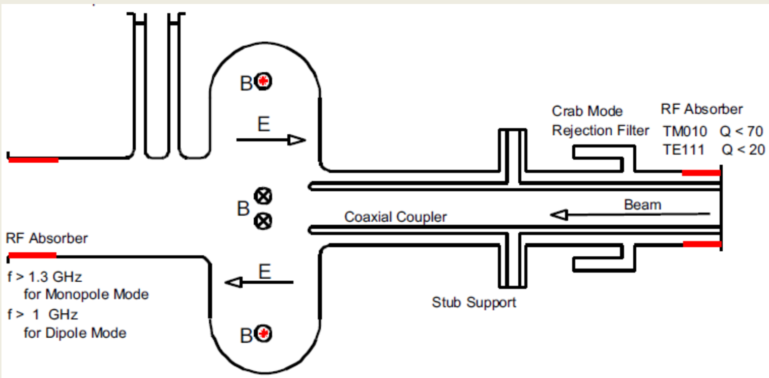
VII. S-matrix method showed that if SS surface is Cu–coated **98% of the HOMs power will end up in the BLAs .**

Talks on HOM Damping Requirements

3. Overview of HOM damping in deflecting cavity Binping Xiao (BNL)

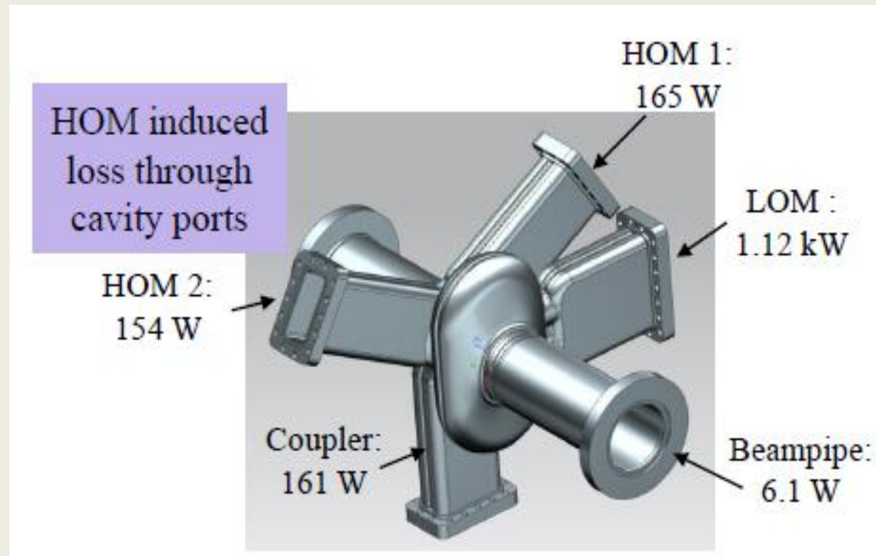
Topics discussed and main message:

I. HOM damping in KEKB and SPX.



- 509 MHz squashed elliptical cavity
- LOM picked up by coaxial coupler, controlled by the insertion of the coaxial
- Choke structure to reject crabbing mode
- Low Q_{ext} for HOMs guarantees low Impedance
- Multipacting easily processed in coax line
- HOM power 16 kW/cav absorbed by ferrites

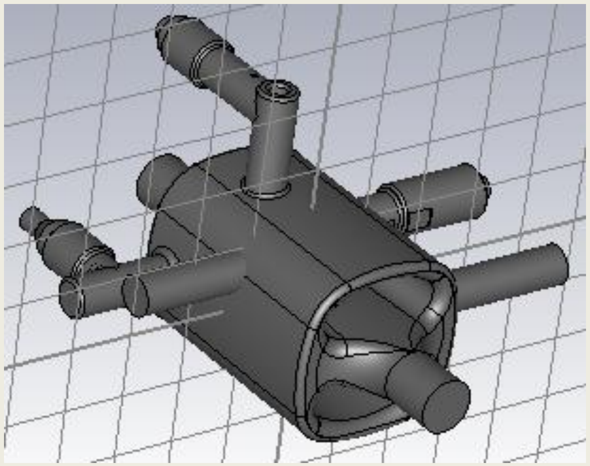
II. SPX Crab Cavity at ANL



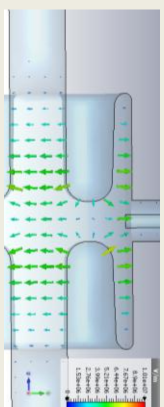
- 2.815 GHz squashed ellipt. cavity, 8^{th} harm
- LOM picked up by waveguide port at the cavity equator
- Y section: 2 ports for HOM, 1 for FPC

3. Overview of HOM damping in deflecting cavity , cont.:

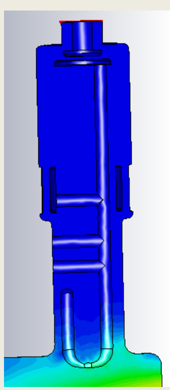
III. HOM damping in RF-dipole and 4-rod for LHC luminosity upgrade



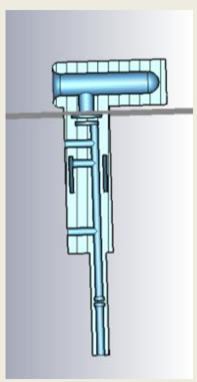
Couplers to provide required HOM damping



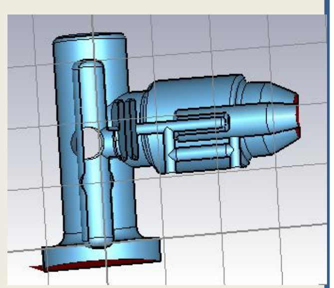
440 MHz coupler



LOM coupler

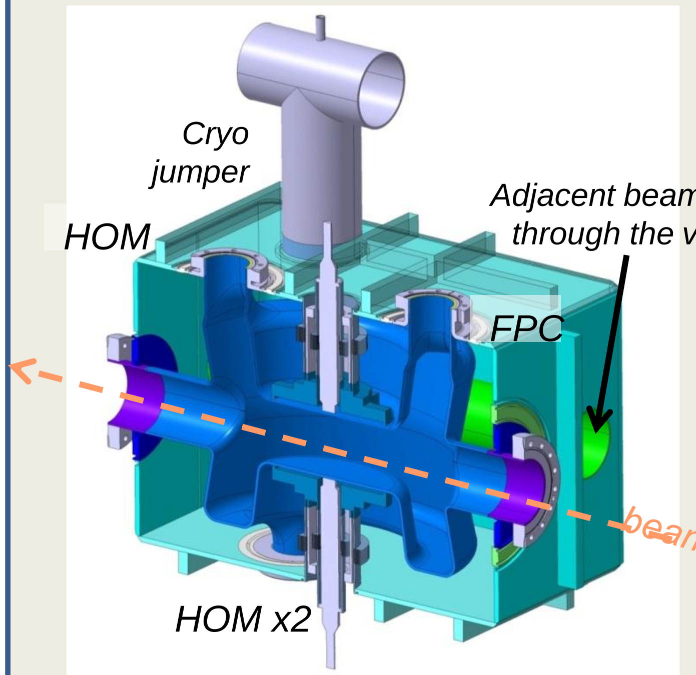


H-HOM coupler

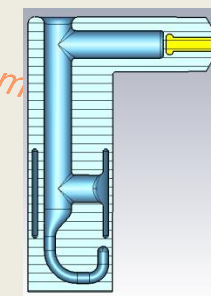


V-HOM coupler

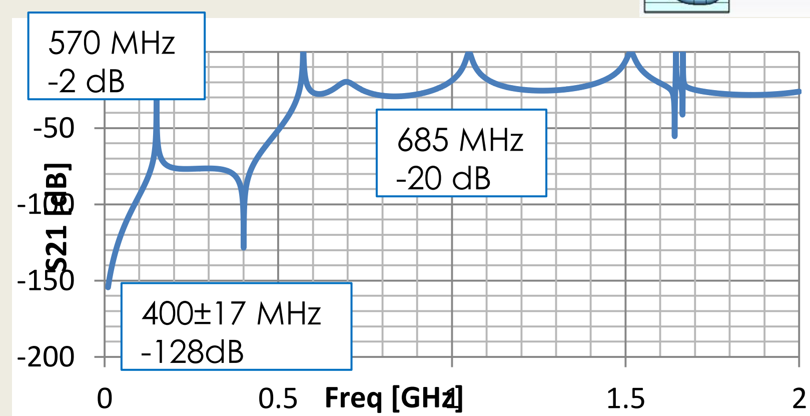
IV. LHC Crab Cavity: DQW (PoP)



Cooling channel



Prototyping in progress



Talks on HOM Damping Requirements

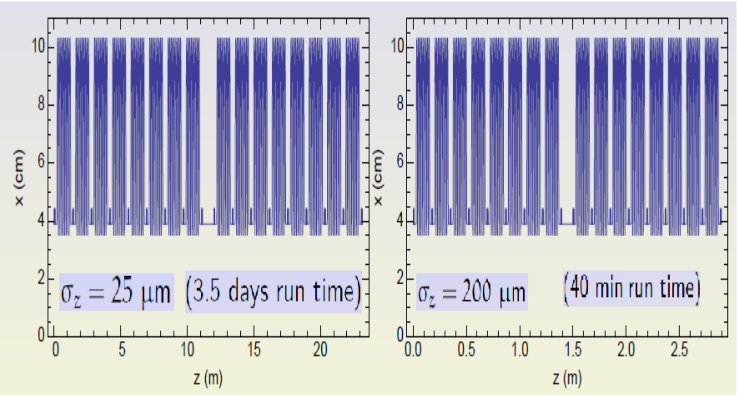
4. Physics of wake potentials of very short bunches Gennady Stupakov (SLAC)

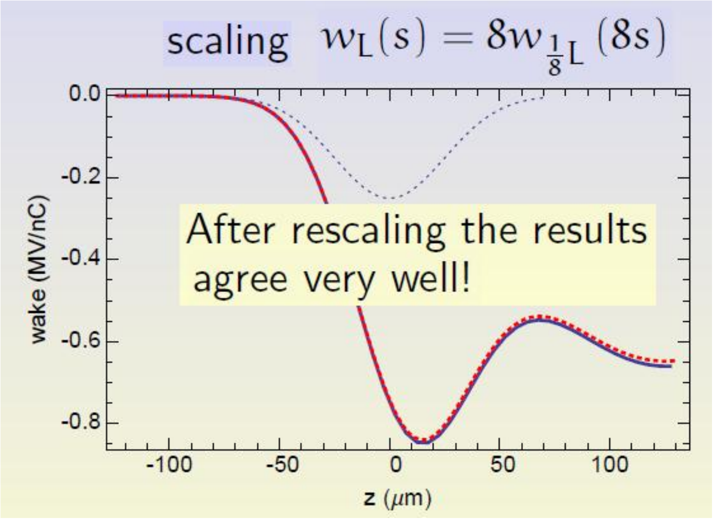
Topics discussed and main message:

The main thesis of this talk: while calculating wakefields of very short bunches is a challenging computational problem, using approximations that take into account the smallness of σ_z can greatly facilitate the job and add additional insight into the physics of wakefields.

- Specificity of wakes for short bunches
- Optical model
- Parabolic equation (PE) for calculation of wakefields
- Scaling properties of the impedance in PE
- Combining computer simulations and analytic wakes

Example of using scaling law





Conclusion

- For large and smooth accelerator structures, and short bunches, direct EM solver calculations can be extremely time and memory-consuming. Using approximate methods that employ small geometric parameters in the problem greatly facilitates the numerical solution.
- Optical approximation and parabolic equation are the new approaches that try to address the issue of wakefield for very short bunches.
- A new method that combines a (processed) long-bunch wake from an EM solver and a singular analytical wake model allows one to accurately obtain wakefields of short bunches, including that of a point-charge.

Talks on HOM Damping Requirements

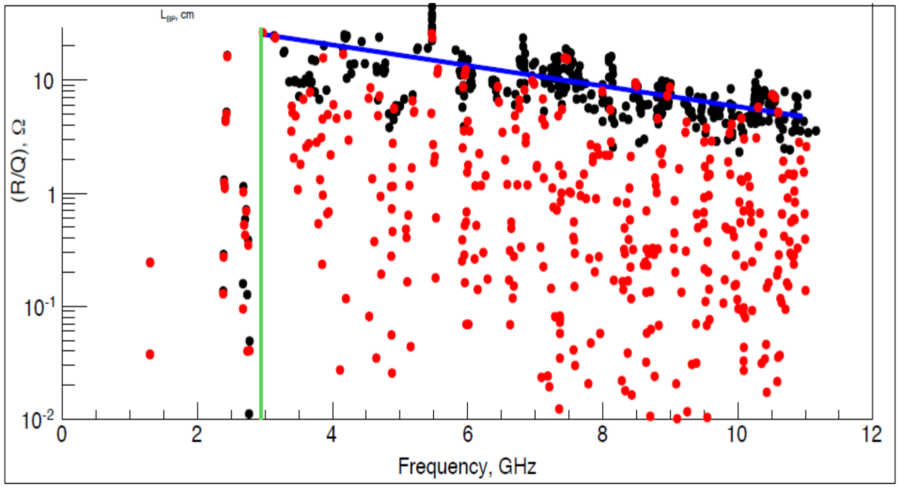
5. Resonance HOM excitation in LCLS-II - Alexander Sukhanov (FNAL)

Topics discussed and main message:

Summary

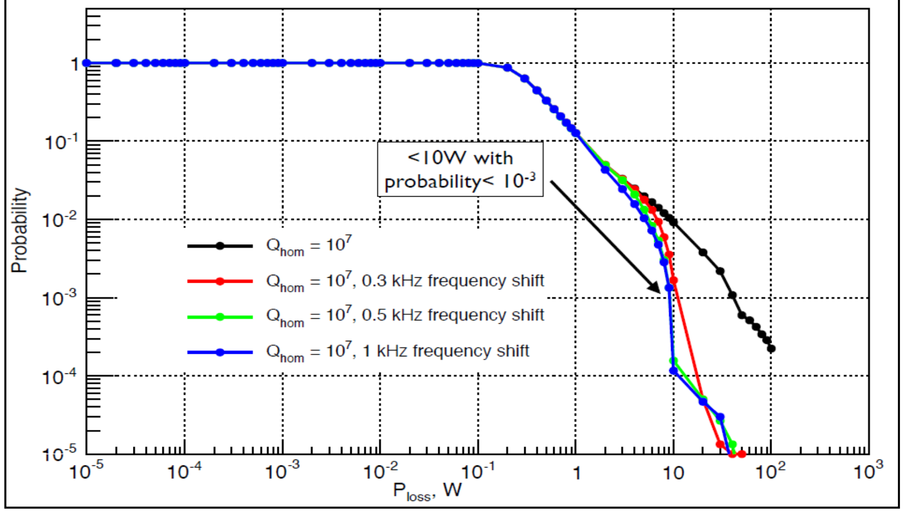
- Analyzed resonance excitation of monopole HOMs in LCLS-II linac
- Median heat load at 2 K < 1 mW
  - heat load > 100 mW has prob. < 5×10^{-4}
- Median power removed by HOM couplers (2 HOM + 1 power coupler per cavity) < 5 W
- Median power dissipated in bellows < 5 W
  - higher power levels can be remedied by HOM spectrum manipulation (detuning cavity and tuning it back, which shifts HOM frequencies by 100s Hz)

Simulations done for 1.3 GHz and 3.9 GHz cryomodules



Power removed by HOM couplers:

- Detune cavity and tune back: HOM frequencies shift by few 100 Hz



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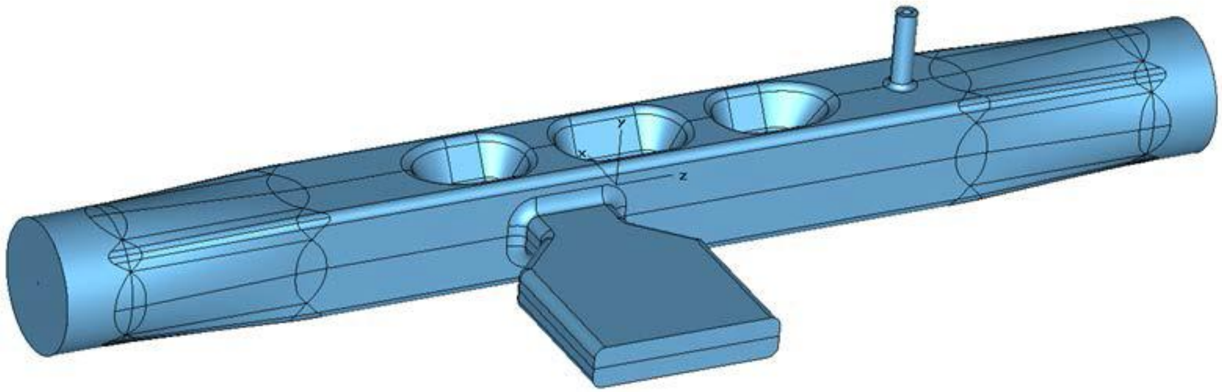
6. HOM-free deflecting cavity - Timergali Khabiboulline (FNAL)

Topics discussed and main message:

New design of crab cavity for APC upgrade (ANL)



Freq	2815 MHz
V_{kick}	2 MV
E_{max}	54 MV/m
B_{max}	75 mT
$(R/Q)_Y$	521 Ω
G	130
Q_{ext}	5.3E5
P_{out}	7.2 kW

- Simple and compact deflecting cavity
- Low surface fields for high Kick voltage
- No HOM couplers; one high power port, used for feeding and dumping of same order modes
- Good damping anyway (HOM radiates through tube ends)
- No multipactoring
- There is no problem with microphonics
- The cavity frequency tuning is feasible

Alternative to Mark-II deflecting cavity